5.7.3 Power Factor Correction

Induction motors, magnetic ballasts, and transformers require two types of power to operate. *Active power* (also called true or real power) produces work or heat, is used by all electrical devices, and is expressed in kilowatts. *Reactive power* is used by inductive devices to generate magnetic fields. It does not perform useful work and is expressed as kVARs (kilovolt-amps reactive). *Total power*, or apparent power, is the vector sum of active and reactive power and is expressed in kVA (kilovolt-amps). A *power factor* is the ratio of active power to total power and quantifies the portion of power used by a facility that does electrically useful work. Power companies generally charge an additional fee to facilities having power factors less than 85–95% in order to capture costs to the utility company that are not reflected by the electric energy (kWh) meter. Improving the power factor can increase current-carrying capacity, improve voltage to equipment, reduce power losses, and lower electric bills.

Opportunities

Efforts should be made to improve power factors if (1) power factors are below 90–95% and penalties charged by the electrical utility are high, (2) electrical problems within the facility can be eliminated by improving the power factor, or (3) installing larger transformers for capacity needs can be deferred. Power factor improvements should be considered whenever electrical equipment such as motors and lighting are being upgraded or replaced.

Technical Information

Electric motors are large contributors to poor power factors because many generally operate under light loads. Lower power factors do not necessarily increase peak kVA demand because of the reduction in load. For example, the power factor of an electric motor is lowest when the motor is lightly loaded. This occurs when both its power draw and contribution to the electrical peak demand is the least.

Power factor correction capacitors are designed to provide the reactive current needed by inductive loads. Capacitors may be installed to improve the power factor of a single load or an entire power system and come in sizes from 1 to 600 kVARs.

Automatic power factor correcting equipment switches banks of capacitors on- and off-line depending on the power factor. These may provide good solutions in applications where reactive loads vary in magnitude over time.

Locate capacitors upstream of motor controllers unless full-voltage, nonreversing, across-the-line starters are used.

☑ Replace standard motors with energy-efficient motors that have high power factor ratings. Note that even high-efficiency motors will have poor power factors under low load conditions—and that efficiency is more important than power factor. Be sure not to sacrifice efficiency for power factor. Avoid operating equipment above its rated voltage. Minimize operation of lightly loaded or idling motors.

Shut down a lightly loaded motor in situations where a smaller, parallel motor can do the same job. For example, when chilled water demand drops, parallel pumps may be removed from service until loads increase.

Be aware that installing power factor correction capacitors on the load side of a motor-overload protection device may require reducing the overload size. The capacitor manufacturer will have tables to assist you in resizing.

Avoid oversizing capacitors installed on the load side of motor controllers because they can discharge into the motor when the controller is turned off. Damaging voltages may occur if kVAR current exceeds motor no-load current.

Note that power factor correction saves money in three basic ways:

- Avoided power factor penalties from the utility (where applicable).
- Freed capacity in supply transformers if such capacity is needed.

Photo: Northeast Power Systems, Inc.

This automated control and protection system includes capacitor banks and harmonic filter banks.

- Reduced I^2R resistive losses in wiring, etc., provided the capacitors are located close to the inductive loads. Kilowatt-hour savings of less than 0.5% are typical, and savings of 1–2% would be the high range for typical commercial and industrial systems.

Beware of applications where there are significant harmonics (VFDs and other nonlinear loads). The harmonics can cause resonances with the capacitors and damage them. If harmonics exist, consider harmonic filters, which also typically improve power factor.

Do not exceed manufacturer's recommendation on maximum capacitor size.

Install high-power-factor lighting and electronic equipment. While motors garner most of the attention regarding power quality, lighting equipment and other electronic products can also have a significant impact on power factor. With lighting, ANSI classifies ballasts with power factors above 0.90 as "high power factor" (HPF). Magnetic ballasts often have far lower power factors (0.50 is typical with some products), as do many types of office equipment (desktop computers, monitors, laser printers, etc.). When data on power factor are available, specify and buy high-power-factor products.

Power factor is less than one when energy is quickly stored and released in a piece of equipment so that the voltage and current are out of phase by the angle Θ.

$$\text{Power factor} = \frac{\text{watts}}{\text{volts*amps}} = \text{Cos}\ \Theta$$

Additional power is not consumed, but bigger wires and transformers are required to handle the additional amps needed by the load. Low power factors of large inductive loads, such as motors, can be improved by adding capacitors to the load. Current through a capacitor has the effect of cancelling out the lagging current.

References

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